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RADIO COMMUNICATION SYSTEM

TECHNICAL FIELD

The present invention relates to a radio communication system for the radio communication between portable radio terminals and a base station in a communication area.

BACKGROUND ART

Referring to Fig. 1 illustrating a radio communication system including portable radio terminals, a base station 1 for a communication area E1 and a base station 2 for a communication area E2 communicate with each other via, for example, a central base station 3. A portable radio terminal 4 in the communication area E1 communicates with the base station 1 by, for example, a frequency division multiple access mode (FDMA mode) or a time division multiple access mode (TDMA mode).

Fig. 2 is a block diagram of the constitution of a portable radio terminal. Shown in Fig. 2 are a transmitter-receiver antenna 10, a radio unit 11, a speech processing unit 12, a central processing unit (CPU) 13, a microphone 14 connected to the speech processing unit 12, a loudspeaker 15 connected to the speech processing unit 12, a ROM 16 storing control programs, a RAM 17 for temporarily storing data being processed, a RAM 18 for storing the respective telephone numbers of the portable radio terminal and a called terminal, a display unit 19, an operating unit 20. The ROM 16, the RAM 17, the RAM 18, the display unit 19 and the operating unit 20 are connected to the CPU 13.

The operation will be described hereinafter.

When numeric keys or an abbreviated number key included in the operating unit 20 of the portable radio terminal 4 is operated for dialing in the communication area E1 of the base station 1. Upon the reception of a dialing signal, the CPU 13 exchanges data with the ROM 16, and the RAMs 17 and 18 to transmit a telephone number signal indicating the telephone number of a called portable radio terminal through the radio unit 11 and the transmitter-receiver antenna 10.

Upon the reception of the telephone number signal, the base station 1 sends a transmission signal through the central base station 3 to the base station 2 for the called portable radio terminal, the base station 2 transmits the transmission signal to a called portable radio terminal 5, and the portable radio terminals 4 and 5 are connected to each other in a talking state. Then, the speech of the caller is converted into a corresponding electric signal by the microphone 14, the electric signal is processed by the speech processing unit 12, and the processed electric signal is transmitted through the transmitter-receiver antenna 10 by the radio unit 11. The speech processing unit 12 receives a transmission signal representing the speech of the caller through the transmitter-receiver antenna 10 and the radio unit 11, and processes the same, and the output of the speech processing unit 12 is converted into the speech by the loudspeaker 15.

During the above talking, the radio unit 11 receives radio waves transmitted by the base station 1 and received through the transmitter-receiver antenna 10 and measures

field intensity level and circuit quality. The CPU 13 compares the field intensity level and the circuit quality measured by the radio unit 11 with certain thresholds. As mentioned in "Daini Sedai Kodoresu Denwa Shisutemu Hyoujun Kikaku Dai-Ippan (Second Generation Cordless Telephone System Standard 1st Edition) (RCRSTD-28)" issued by Zaidan Hojin Denpa Shisutemu Kaihatsu Senta (Dec., 1993), the thresholds are communicated beforehand by the base station as "handover processing level" to the portable radio terminal.

As the result of the comparison, if the field intensity level or the circuit quality is justified below the threshold, the CPU 13 provides a handover instruction and the radio unit 11 starts a handover operation upon the reception of the handover instruction.

Since the conventional radio communication system has the foregoing configuration, the handover operation is repeated at intervals of, for example, 5 sec when the quality of the received radio waves is unsatisfactory and is below the threshold even if there is no base station available for handover, and the speech is interrupted for 2 sec for the handover operation, which deteriorates speech quality greatly.

The present invention has been made to solve such a problem and it is therefore an object of the present invention to improve speech quality by reducing the frequency of the handover operation if there is no base station available for handover.

DISCLOSURE OF INVENTION

The present invention avoids unnecessarily frequent repetition of a handover operation to improve communication quality by employing a radio unit connected to a transmitter-receiver antenna, and a control unit which compares either or both of field intensity level and circuit quality measured by the radio unit with thresholds, and gives a handover instruction to the radio unit if the measured field intensity level or the measured circuit quality is lower than the corresponding threshold, and lowers the threshold when a handover operation carried out in response to the handover instruction is unsuccessfully executed.

The present invention avoids the unnecessary change of conditions for handover in an area where communication condition is satisfactory by employing a selecting unit which selects either a procedure to change conditions for handover when a handover operation is unsuccessfully executed, or a procedure to keep conditions for handover unchanged even if a handover operation is unsuccessfully executed.

The present invention reduces the frequency of an unnecessary handover operation to improve communication quality by changing time when the next handover operation can be started according as a handover operation is unsuccessfully done.

The present invention reduces the frequency of an unnecessary handover operation to improve communication quality by changing either or both of a time when the next handover operation can be started, and the thresholds to be compared with field intensity level and circuit quality

measured by the radio unit when a handover operation is unsuccessfully executed.

The present invention avoids the unnecessary change of conditions for handover in an area where communication condition is satisfactory by changing either or both of time when the next handover operation can be started and the thresholds to be compared with field intensity level and circuit quality measured by the radio unit when a handover operation is successful.

The present invention enables the operator to execute a forced handover operation by employing a radio unit connected to a transmitter-receiver antenna, a control unit which compares either or both of field intensity level and circuit quality measured by the radio unit with thresholds, gives a handover instruction to the radio unit if the measured field intensity level or the measured circuit quality is lower than the corresponding threshold, and lowers the threshold if a handover operation carried out in response to the handover instruction is unsuccessfully executed, and a handover executing means capable of forcibly executing handover regardless of either or both of the field intensity level and the circuit quality.

The present invention enables the operator to inhibit handover to reduce the frequency of unnecessary handover and to improve communication quality by employing a radio unit connected to a transmitter-receiver antenna, a control unit which compares either or both of field intensity level and circuit quality measured by the radio unit with thresholds, gives a handover instruction to the

radio unit if the measured field intensity level or the measured circuit quality is lower than the corresponding threshold, and lowers the threshold if a handover operation carried out in response to the handover instruction is unsuccessful, and a handover inhibiting means capable of inhibiting the execution of handover regardless of either or both of the field intensity level and the circuit quality.

BRIEF DESCRIPTION OF DRAWINGS

Fig. 1 is a diagrammatic view of a radio communication system including portable radio terminals;

Fig. 2 is a block diagram of a portable radio terminal;

Fig. 3 is a flow chart of a procedure to be carried out by a radio communication system in a first embodiment according to the present invention;

Fig. 4 is a flow chart of a procedure to be carried out by a radio communication system in a second embodiment according to the present invention;

Fig. 5 is a flow chart of a procedure to be carried out by a radio communication system in a third embodiment according to the present invention; and

Fig. 6 is a flow chart of a procedure to be carried out by a radio communication system in a fourth embodiment according to the present invention.

BEST MODE FOR CARRYING OUT THE INVENTION

The present invention will be described in terms of the best mode for carrying out the invention with reference

to the accompanying drawings.

First Embodiment

A radio communication system in a first embodiment according to the present invention and portable radio terminals included in the radio communication system are the same in construction as those shown in Figs. 1 and 2. New functions are added to a radio unit 11, a CPU 13 and an operating unit 20, i.e., components of the portable radio terminal.

Fig. 3 is a flow chart of a procedure to be carried out by the radio communication system in the first embodiment of the present invention. Upon the start of the procedure, a threshold is set to a default threshold TH0 in step ST1.

As shown in Fig. 2, the radio unit 11 measures either or both of received field intensity level and circuit quality, and gives either or both of the measured field intensity level and the measured circuit quality to the CPU 13. The CPU 13 compares either or both of the measured field intensity level and the measured circuit quality with the thresholds in step ST2. A query is made in step ST3 to see if either of the measured field intensity level and the measured circuit quality is lower than the corresponding threshold. Steps ST2 and ST3 are repeated if the response in step ST3 is negative. The CPU 13 gives a handover instruction to the radio unit 11 in step ST4 if the response in step ST3 is affirmative.

Subsequently, the radio unit 11 executes a handover operation in response to the handover instruction, makes a query in step ST5 to see if the handover operation is

successfully done, and changes the threshold to a new threshold lower than the default threshold TH0 in step ST6 if the handover operation is failed. Therefore, the next handover operation is started if the measured field intensity level or the measured circuit quality is lower than the new threshold. Consequently, the frequency of repetition of the handover operation is reduced if the field intensity level or the circuit quality remains unchanged.

If it is justified in step ST5 that the handover operation is successful, the threshold is restored to the previous threshold TH0.

Second Embodiment.

Fig. 4 is a flow chart of a procedure to be carried out by a radio communication system in a second embodiment according to the present invention. In this radio communication system, a threshold is changed in steps according to the frequency of unsuccessful handover operations.

Upon the start of the procedure, a threshold is set to a default threshold TH0 in step ST11, and a handover failure frequency n is set to zero ($n = 0$) in step ST12.

A radio unit 11 measures either or both of received field intensity level and circuit quality, and gives either or both of the measured field intensity level and the measured circuit quality to a CPU 13. The CPU 13 compares either or both of the measured field intensity level and the measured circuit quality with the thresholds in step ST13. A query is made in step ST14 to see if either of

the measured field intensity level and the measured circuit quality is lower than the corresponding threshold. Steps ST13 and ST14 are repeated if the response in step ST14 is negative. The CPU 13 gives a handover instruction to the radio unit 11 in step ST15 if the response in step ST14 is affirmative.

Subsequently, the radio unit 11 executes a handover operation in response to the handover instruction, makes a query in step ST16 to see if the handover operation is successful, and increases the handover failure frequency by 1 in step ST17 and sets the threshold to a lower default threshold Thn in step ST18 if the handover operation is unsuccessful. For example, n = 2 if two successive handover operations are unsuccessful and the threshold is set to a lower default threshold.

If the handover operation is successful, the handover failure frequency n is restored to zero in step ST19, and the threshold is set to the default threshold TH0 in step ST20; that is, the initial set state is restored.

Third Embodiment

The second embodiment carries out a threshold lowering operation to lower the threshold when the handover operation results in a failure or carries out a initial threshold restoring operation to restore the initial threshold when the handover operation is successful. An operating unit 20 included in a third embodiment of the present invention is provided with a selecting means, not shown, for selecting either an operating mode in which the threshold lowering operation or the initial threshold

restoring operation is carried out or an operating mode in which the threshold lowering operation or the initial threshold restoring operation is not carried out. Fig. 5 is a flow chart of a procedure to be carried out by the third embodiment of the present invention.

Upon the start of the procedure, a threshold is set to a default threshold TH0 in step ST21.

A radio unit 11 measures either or both of received field intensity level and circuit quality, and gives either or both of the measured field intensity level and the measured circuit quality to a CPU 13. The CPU 13 compares either or both of the measured field intensity level and the measured circuit quality with the thresholds in step ST22. A query is made in step ST23 to see if either of the measured field intensity level and the measured circuit quality is lower than the corresponding threshold. Steps ST22 and ST23 are repeated if the response in step ST23 is negative. The radio unit 11 provides a handover instruction and executes a handover operation in step ST24 if the response in step ST23 is affirmative.

Then, a query is made in step ST25 to see if the handover operation is successful. A query is made in step ST26 to see if the input is fixed. The threshold is kept unchanged if the input is fixed or the threshold is changed in step ST27 if the input is variable. If it is decided in step ST25 that the handover operation is successful, a query is made in step ST28 to see if the input is variable. The threshold is kept unchanged if the input is fixed or the threshold is restored to the default threshold in step ST29 if the input is variable.

Fourth Embodiment

In the first embodiment, the threshold is lowered if the handover operation is unsuccessful or the threshold is restored to the initial threshold if the handover operation is successful. The execution of the next handover operation may be suspended for a fixed period of time. Fig. 6 shows a procedure to be carried out by radio communication system in a fourth embodiment according to the present invention.

Upon the start of the procedure, handover inhibit time is set to a default handover inhibit time in step ST31. Subsequently, a radio unit 11 measures either or both of received field intensity level and circuit quality, and gives either or both of the measured field intensity level and the measured circuit quality to a CPU 13. The CPU 13 compares either or both of the measured field intensity level and the measured circuit quality with the thresholds in step ST32. A query is made in step ST33 to see if either of the measured field intensity level and the measured circuit quality is lower than the corresponding threshold. Steps ST32 and ST33 are repeated if the response in step ST33 is negative. The CPU 13 makes a query to see if handover is inhibited in step ST34 when the response in step ST33 is affirmative. If the response in step ST34 is affirmative, the procedure returns to step ST32 or a handover operation is executed in step ST35 if the response in step ST34 is negative.

Then, a query is made in step ST36 to see if the handover operation is successful. The initial handover inhibit time is restored if the handover operation is

successful in step ST37 or step ST38 is executed to change the handover inhibit time when the handover operation is unsuccessful and the procedure returns to step ST32 and the foregoing steps are repeated.

Thus, the next handover operation is started after the elapse of the new handover inhibit time, which reduces the frequency of handover operations.

Fifth Embodiment

The fourth embodiment suspends the next handover operation for a fixed period of time if the preceding handover operation is unsuccessful. The handover inhibit time may be changed in steps according to the frequency of unsuccessful handover operations. For example, if two successive handover operations resulted in a failure, the handover inhibit time for which the next handover operation is suspended may be extended. The handover inhibit time may be changed according to the frequency of unsuccessful handover operations.

Sixth Embodiment

Although the fourth embodiment suspends the next handover operation for a fixed period of time if the preceding handover operation is unsuccessful, the operating unit 20 may be provided with a selecting means for selecting either an operation to suspend the next handover operation for a fixed period of time or an operation not to suspend the next handover operation for a fixed period of time.

Seventh Embodiment

Although the first to the third embodiments change conditions for handover when a handover operation is unsuccessful and the fourth to the sixth embodiments change time when handover can be started, both conditions for handover and time when handover can be started may be simultaneously changed.

Eighth Embodiment

Although the first to the seventh embodiments change conditions for handover if a handover operation is unsuccessful, conditions for handover may be changed when a handover operation is successful. For example, it is possible to monitor the frequency of handover operations continuously to change the thresholds or to change time when the handover is to be started when the frequency of handover operations exceeds a predetermined value.

Ninth Embodiment

Although the first to the eighth embodiments start a handover operation when the measured field intensity level or the measured circuit condition provided by the radio unit 11 is lower than the corresponding threshold, the handover may be started or may be inhibited depending on an operator's request, i.e., a request signal provided by operating the operating unit 3, not depending on the output of the radio unit 11.

INDUSTRIAL APPLICABILITY

As is apparent from the foregoing description, the

radio communication system of the present invention lowers the threshold defining the lower limit of conditions not requiring handover if a handover operation is unsuccessful. Therefore, an unnecessary handover operation in a state where any base station for handover cannot be found can be avoided to improve communication quality.